CLAIMS

1.   An electrodeionization apparatus comprising dilute cells and concentrate cells defined between ion permeable membranes, said dilute and concentrate cells being arranged between an anode electrode and a cathode electrode, and configured such that ions present in a flow of feed water passing through a dilute cell are captured by exchange resin and move under influence of an electric potential applied by the electrodes into adjacent concentrate cells, being thereby removed from the flow so as to form an at least partially deionized product water, and wherein at least some of said cells contain a sparse distribution of ion exchange resin.

2.   The electrodeionization apparatus of claim 1, wherein the ion exchange resin includes beads having a nominal diameter, and the dilute cell has a thickness under about twice said diameter, said sparse distribution having a packing density effective to maintain membrane spacing and to effect ion conduction across the cell while providing an effective flow-passing porosity.

3.   The electrodeionization apparatus of claim 2, wherein the sparse distribution is a bed of beads having a thickness of approximately two diameters.

4.   The electrodeionization apparatus of claim 2, wherein the sparse distribution is a layer having a thickness of approximately one diameter.

5.   The electrodeionization apparatus of [any of claims 1-4] claim1, wherein the sparse distribution is a bed selected from among a mixed bed, a layered bed, a striped bed, a graded bed and a monotype bed.

6.   The electrodeionization apparatus of [any of claims 1-4] claim 1, wherein the sparse distribution is stabilized in position by a mesh.

7. The electrodeionization apparatus of claim 1, wherein the sparse distribution is a distribution of beads and the apparatus contains a screen having a mesh size greater than one bead dimension for stabilizing the filling.

8. The Electrodeionization apparatus of [any of claims 1-6] claim 1, wherein the sparse distribution is stabilized by beads fixed on a screen by adhesion, electrostatic, magnetic or electronic interaction.

9. A method of filling an EDI cell, such method comprising the steps of
    assembling a spacer on a first membrane, wherein the spacer defines a fluid flow region adjacent the first membrane
    sprinkling ion exchange beads into the flow region as a sparse distribution, and assembling a second membrane over the spacer
    thereby forming a sparsely filled EDI cell.

10. The method of claim [8] 9, further comprising the step of providing a mesh in the flow region, the mesh forming a reticulation of strands criss-crossing the flow region such that the mesh segregates and supports the beads of the sparse distribution.

11. An EDI apparatus [comprised of a plurality of dilute cells alternating with concentrate cells, each dilute cell being defined between an anion exchange membrane and a cation exchange membrane, and a] according to claim 1, wherein the sparse distribution is comprised of substantially mutually separate ion exchange beads in the cell for stripping ions from fluid passing through the cell and conducting stripped ions to an adjacent membrane.

12. The EDI apparatus of claim 11, wherein a substantial portion of said mutually separate ion exchange beads contact both said anion exchange membrane and said cation exchange membrane.

13.   The EDI apparatus of claim 12, wherein the substantial portion of beads are urged into deforming contact at surfaces of said anion exchange membrane and said cation exchange membrane to provide enhanced conductivity therebetween.

14.   EDI apparatus [comprised of a plurality of dilute cells alternating with concentrate cells, the cells being defined between an anion exchange membrane and a cation exchange membrane, and comprising] according to claim 1, wherein the sparse distribution comprises a monolayer of mixed type ion exchange beads positioned between the anion exchange membrane and the cation exchange membrane.

15.   EDI apparatus [comprised of a plurality of dilute cells alternating with concentrate cells, each cell being defined between a first membrane and a second membrane, and a layer of ion exchange beads positioned between the first membrane and the second membrane, wherein the layer is] according to claim 1, wherein the sparse distribution comprises a layer substantially free of bead-to-bead reverse junctions.

16.   The EDI apparatus of claim 15, wherein said layer is a monolayer or an ordered bilayer.

17.   EDI apparatus [comprised of a plurality of dilute cells alternating with concentrate cells, each dilute cell being defined between a first ion exchange membrane and a second ion exchange membrane, and ion exchange beads positioned between the first ion exchange membrane and the second ion exchange membrane, the] according to claim 15, comprising ion exchange beads including anion exchange beads and cation exchange beads for stripping ions from fluid passing through the cell, said beads being positioned in a layer configured to not throw salt as applied voltage is increased in operation.

18.   EDI apparatus [comprised of a plurality of dilute cells alternating with concentrate cells, each dilute cell being defined between a first ion exchange membrane and a second ion exchange membrane, and ion exchange beads positioned between the

first ion exchange membrane and the second ion exchange membrane, the ion exchange beads including] according to claim 1, wherein the ion exchange resin includes anion exchange beads and cation exchange beads for stripping ions from fluid passing through the cell, said beads being positioned in a sparse layer of substantially non-contiguous beads substantially free of reverse bead junctions, and wherein individual beads contact both said first and said second membrane and conduct ions to a single membrane under influence of a transversely-applied electric field.

19.   EDI apparatus [comprised of a plurality of dilute cells alternating with concentrate cells and positioned between electrodes,] according to claim1 wherein a cell is defined between a first ion exchange membrane having protruding bumps of ion exchange material and a second ion exchange membrane, wherein the protruding bumps of ion exchange material support the first and second membranes apart defining a flow space under about one millimeter thick between said membranes said bumps comprising the sparse distribution of ion exchange resin.

21.   An improved method of forming a resin filled EDI cell, such method comprising the steps of arranging a plurality of ion exchange membranes between a pair of electrodes configured to apply an electric field transversely to said membranes, and providing a sparse distribution of ion exchange material between adjacent ones of the membranes.

21.   An improved method of purifying fluid by electrodeionization, wherein the improvement is characterized by the step of providing a sparse distribution of ion exchange material in one or more types of cells within an electrodeionization apparatus.

22.   The method of claim 21, wherein the sparse distribution is provided in one or more cells selected from the group of cells consisting of dilute cells, concentrate cells and electrolyte cells, said sparse distribution comprising monotype resin (preferably in concentrate cells) or mixed type resin.

23. (Canceled)   The method of claim 22, wherein the sparse distribution comprises both anion exchange resin and cation exchange resin.

24. (Canceled)   The method of claim 22, wherein the sparse distribution comprises a single type of resin (anion exchange or cation exchange type of resin).

25. (Canceled)   The method of claim 24, wherein the single type is provided in concentrate cells.

26. (Canceled)   Apparatus for filling EDI cells comprising a deposition assembly for sprinkling a controlled quantity of ion exchange beads as a sparse distribution in an EDI flow chamber.

27.   A method of forming a layer of ion exchange beads wherein the method includes the step of wet sieving beads through a screen to capture the layer in the screen.

28. (Canceled)   A method of forming a distribution of ion exchange beads in a cell of an electrodeionization apparatus, wherein the method includes the steps of positioning a sparse distribution of said beads and restraining movement of the beads with a mesh to provide a stable sparse bead distribution in the cell.